DESIGN, IMPLEMENTATION, AND EVALUATION OF A RELATIONAL DATABASE ENGINE FOR VARIABLE LENGTH RECORDS

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ABSTRACT

This paper reports the design, implementation, and evaluation of a relational database engine. The engine has special purpose hardware, the nucleus of which is a pipeline two-way merge sorter, to execute sorting and relational algebra for variable length records. In the execution of these operations, key fields are extracted from records. The engine has on-the-fly processing in which it inputs data directly from disk. The evaluation shows the characteristics of processing time, the effect of variable length records, and the effectiveness of on-the-fly processing.

INTRODUCTION

The Institute for New Generation Computer Technology (ICOT) considers that fifth generation computer systems have the integrated functions of inference and knowledge bases, and has been researching and developing inference machines (IMs) and knowledge base machines (KBMs). For KBMs, a relational database machine, Delta (1,2), was developed because the relational database is said to be suitable for logic programming which is used in IMs. In Delta, facts, as in Prolog, are stored as relations and retrieved by relational algebra. Another KBM is now under development, in which Horn clauses are stored as relations and retrieved by operations called retrieval-by-unification (RBU) (3). In RBU operations, data is selected and joined based on unifiability, in contrast to relational algebra, in which data is selected and joined based on equality. The KBM has unification engines (UEs) (4), which perform RBU operations. Although a Horn clause is represented as a structure which consists of literals and variables, UEs treat the structure as a variable length string.

With this background, we have developed a relational database engine (RDBE) with following aims.

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Processing variable length records using hardware

The RDBE performs sorting and relational algebra (RA) operations for one fixed or variable length key field in variable length records.

Efficient database processing

On-the-fly processing. To process data on disk efficiently, the RDBE has on-the-fly processing in which it inputs data directly from disk. Without on-the-fly processing, data on disk is loaded to main memory (MM) before it is input to the RDBE, then the data path in the entire processing is "disk → MM → RDBE → MM". On-the-fly processing makes the data path "disk → RDBE → MM", and achieves more effective processing.

Stream processing in the RDBE. The RDBE realizes the stream processing of sorting and RA operations.

The search processor, SHP (5), is an example of a processor which has on-the-fly processing. Examples of processors which have stream processing are VLSIs based on the systolic array (6), the RDBE in Delta (7), multiple processors for the join operation (8), and some processors for sorting, for example, a sort engine using pipeline heap sorting (9) and a pipeline merge sorter (10). An algorithm has been proposed for a sorting processor for variable length records (11), but has not been implemented yet.

Later sections discuss the design, implementation, and performance evaluation of the RDBE. Section 2 presents the basic ideas of design and features of the RDBE. Section 3 summarizes the configuration, format of data to be processed, functions, and processing. Section 4 shows the implementation of all components of the RDBE. Section 5 evaluates performance based on the design values and measurement.

BASIC IDEAS

Configuration of the Database Machine

Fig. 1 shows the configuration of the database machine. It mainly consists of a central processing unit (CPU), MM, RDBE, and database disk. Relations manipulated by the database machine have both fixed and variable length attributes. Relation schemata and data are stored in different files on disk. Data of one relation is stored in one file. One record in a file corresponds to one tuple in a relation. Fig. 2 shows the structure of a record.

![Fig. 1. Configuration of the Database Machine](image)